

APPENDIX B

ARMY CRATER REPAIR

Joint service regulation AR 415-30/AFR 93-10 requires the Army to conduct emergency repair of war-damaged air bases where requirements exceed the Air Force's organic repair capability. Since the Army has a contingency mission for performing emergency repair of air bases, Army engineer units must train using Air Force crater repair methods covered in Appendix A. These emergency repair methods are preferred if materials are available.

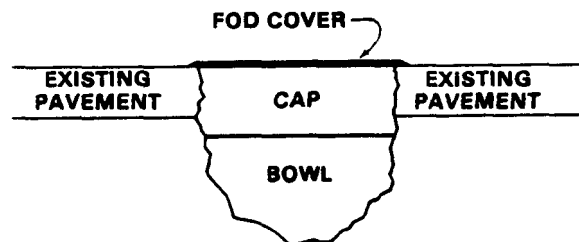
For rapidly deployable forces and for use on air bases and Army airfields, the Army has developed the sand grid method as an alternate emergency repair solution. Army engineer units, especially light, airmobile, and airborne, should train with the sand grid method since it is easily emplaced and provides an acceptable emergency repaired surface. The sand grid method is lightweight, air transportable, and does not require prestocked supplies of either crushed stone or concrete slabs, which makes it particularly useful to these units.

Additionally, the Army is required to repair and restore air base damage beyond emergency repair. Beyond emergency repairs upgrade Air Force emergency repairs or unrepaired craters and spans, and require the use of materials similar to those of the original construction. For beyond emergency repairs, the Army has developed two techniques. These techniques are a concrete cap and a stone and grout cap.

GENERAL CRATER REPAIR ACTIVITIES

Certain repair procedures are standard for all Army repair methods. Crater preparation consists of preparing both the crater "bowl" and the crater "cap" (see Figure B-1). The bowl consists only of backfilled debris and aggregate. It provides foundational support for the cap. The cap consists of either sand grids overlain by an FOD cover, concrete, or stone and grout. It provides some strength, acts as a sealant against moisture, and restores a suitably smooth runway surface.

FIGURE B-1. CRATER BOWL AND CAP



In preparing the bowl, all standing water must be removed from the crater bottom by the most efficient means available. This is necessary to allow for proper compaction of subsequent fill layers and to avoid an excessive settlement of the cap. Pneumatic pumps are ideally suited for water removal.

The debris and small heaved material (no dimension greater than 12 inches) are placed back into the crater, in layers, and compacted to at least 85 percent compactive effort (CE) 55 California Bearing Ratio (CBR) of approximately 4. All oversized, large debris is then pushed away from the site.

Aggregate must be loaded and transported from the quarry/stockpile to the crater site. Improper compaction is most often the cause for crater repair failure. Speed is important, but it is critical to stress compaction quality control.

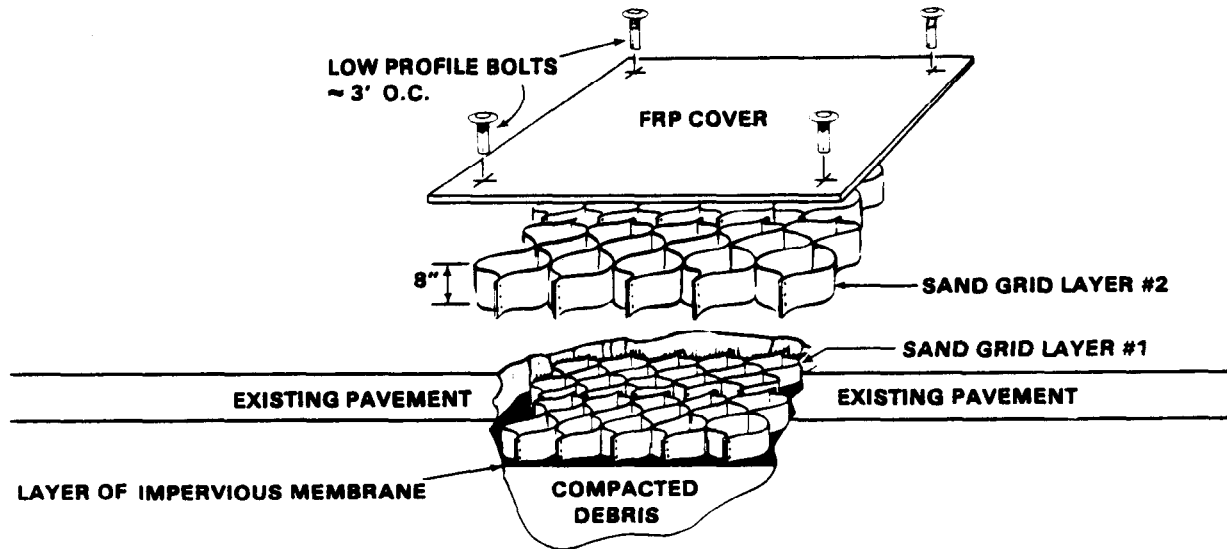
Throughout the repair operation, the runway must be cleared of all foreign objects and debris which might interfere with the resumption of emergency aircraft operations.

EMERGENCY REPAIR

Sand Grid

The sand grid repair is a rapidly deployable, lightweight, and inexpensive RRR technique. The sand grid, with a cover of FRP mat, is designed to withstand 1,000 sorties of an F4 (or 500 sorties of an F15), 200 sorties of a C141B, and 300 sorties of a C130. The sand grid repair method is performed as follows:

- Backfill the crater with compacted debris not higher than 16 inches below the existing pavement. Place an, impervious membrane on top of the debris. This prevents inflow of the water table into the sand grid. Also, the membrane prevents the sand in the sand grid from filtering into the debris and causing localized failure and short-term differential settlement in the runway surface.
- Place one layer of sand grid on top of the compacted ejects (debris). Use pickets or place sand on the corners and sides to prevent the accordion-like sand grid retracting to its original form. Using a bucket loader, fill in the sand grid from the near end to the far end. Personnel using hand shovels should ensure that each grid is completely filled with sand. Once a sand grid section is filled with sand, it will support the weight of a bucket loader. The bucket loader can then walk on the completed portions of the sand grid and progressively dump sand into unfilled portions of the sand grid.
- Once the entire first layer of sand grid has been filled with sand, place a second layer of sand grid on top of the first layer. Offset the second layer so that the edges of both layers of sand grid do not line up directly (see Figure B-2). Fill the second sand grid using the same procedure as for the first layer. Fill in any low spots by hand.

FIGURE B-2. SAND GRID REPAIR

- Place an FRP mat or M-19 matting on top of the repair to prevent FOD.
- For maintenance of the sand grid, use a bucket loader with chains to pick up the edge of the FRP mat or remove the mat entirely so that more sand can be added to the sand grid layers. Replace the FRP mat and secure it to the pavement.

BEYOND EMERGENCY REPAIR

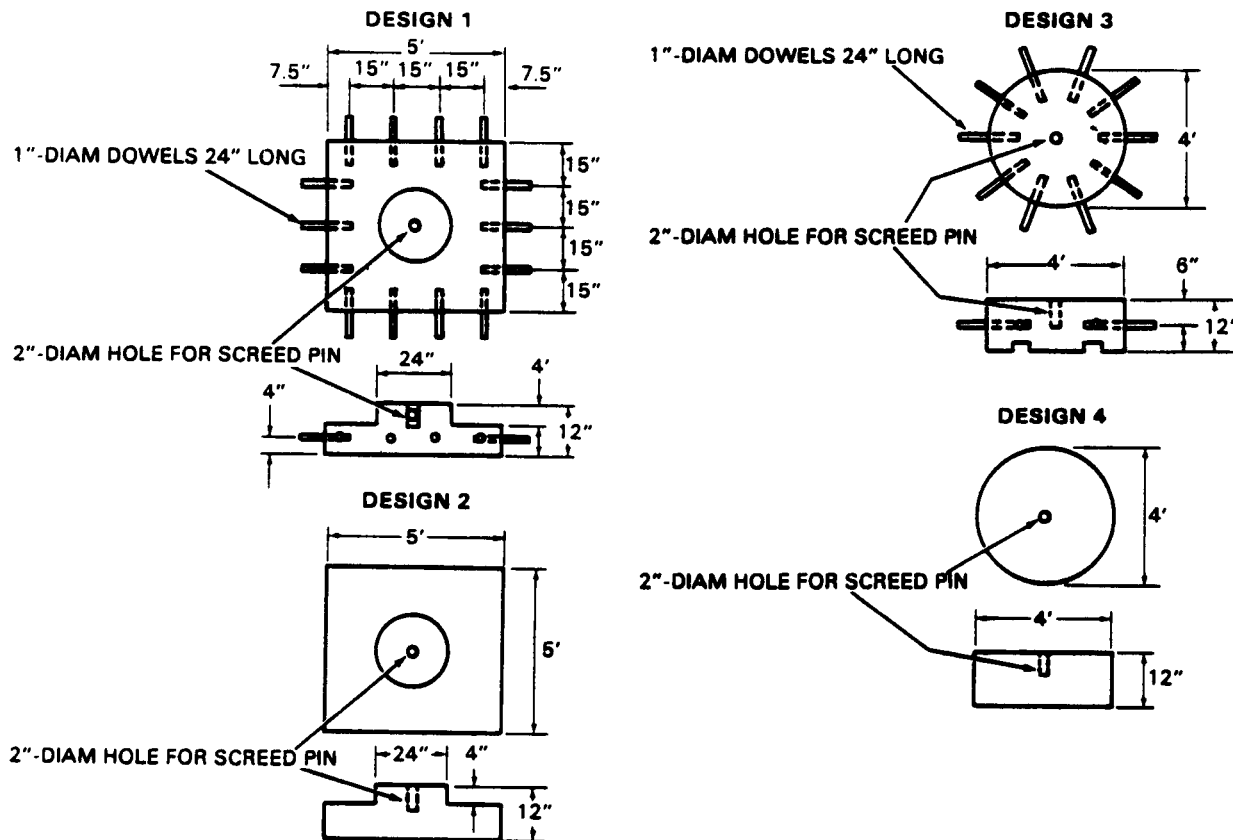
Concrete Cap

Backfill the crater with compacted debris not higher than 28 inches below the existing pavement. Place well-graded crushed aggregate on the compacted debris in lifts having thickness of 12 inches or less. When the surface of the newly placed lift is sufficiently lower than the surrounding pavement, a ramp of the same material might be required for equipment to enter and exit the crater. The lower lift must be compacted to 95 percent CE 55 and the top lift must be compacted to 100 percent CE 55 density. The top lift terminates at least 12 inches below the existing pavement. Compaction effort around the edges must match the compactive effort being made in the crater interior. This is best accomplished using plate compactors and hand-tampers. Improper compaction is most often the cause for repair failure.

For craters smaller than 30 feet in diameter, screeding can generally be performed by hand. When single craters or overlapping craters form a damaged area greater than 30 feet in diameter, a screed method using a concrete pedestal is recommended. It is highly advisable for

Army units to prefabricate concrete pedestals (see Figure B-3). Ask the BCE to include these pedestals in prestocked supplies at the air base.

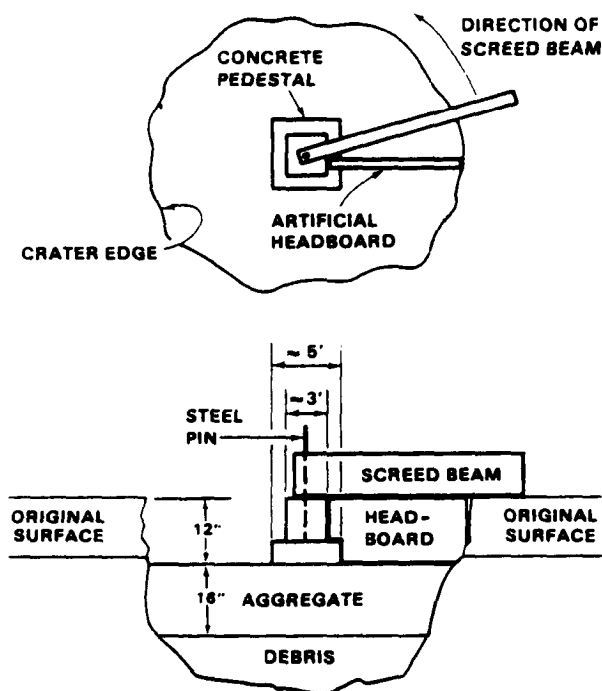
FIGURE B-3. PEDESTAL DESIGNS



Prepare the center of the crater so that the surface of the prefabricated concrete pedestal is even with the surface of the runway pavement (see Figure B-4). This is best accomplished with a string line.

Secure the screed beam to the pedestal by placing a steel pin through the beam into the slot in the pedestal. Clean the edges of the crater and place a starter form in the crater. The starter form is an artificial headboard form which allows the concrete to be rapidly leveled as it is placed into the crater. The starter form is removed from the crater as soon as the placement is completed. Experience has shown that load transfer devices (such as dowels) are not needed to permit better bonding to the existing runway.

Placement of the 12-inch concrete cap is dependent upon concrete materials for the concrete-mobile trucks or host nation support for ready-mix concrete trucks. Portland cement concrete

FIGURE B-4. CONCRETE CAP USING PEDESTAL

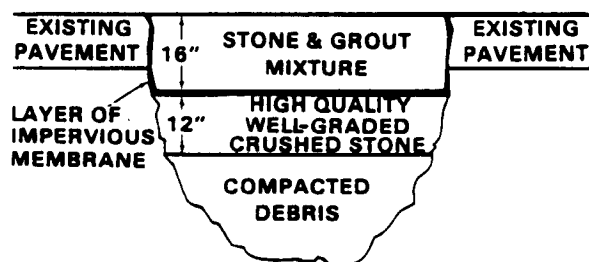
may be made with either Type I/Normal or Type III/High-Early cement. Whether the concrete is ordered or made on site, the concrete must achieve a compressive strength of at least 1,500 pounds per square inch (psi) within 24 hours.

It is critical to ensure a homogeneous placement of the concrete cap. At least three concrete ready-mix or concrete-mobile trucks should be pre-positioned around the crater to allow an initial steady placement of concrete into the crater. Finish the surface until it is smooth and level with the surrounding pavement (see Figure B-4). An accelerator must be added to quicken the curing time. The concrete must be allowed to cure at least 24 hours before trafficking fighter aircraft.

STONE AND GROUT CAP

Placement at or Above Freezing Temperatures

Backfill the crater with compacted debris not higher than 28 inches below the existing pavement. Place well-graded crushed stone on the compacted debris in lifts with lift thickness not to exceed 12 inches. Compact to 95 percent CE 55. The top lift terminates 16 inches below the existing pavement (see Figure B-5). Compaction effort around the edges must match the compactive effort being made elsewhere (use plate compactors and hand-tampers).

FIGURE B-5. STONE AND GROUT CAP REPAIR

Clean the edges of the crater thoroughly and place a layer of sand approximately 1 foot wide by 1 to 2 inches deep around the entire inside of the crater. This is to prevent seepage of the grout around the edge of the crater.

Place impervious membrane (such as polyethylene, visqueen, or T-17 air base membrane) over the entire gravel surface.

Fill the crater cap approximately 50 percent full with grout. This places the grout at a level about 8 inches below the existing pavement (see Table B-1 for a grout mixture). Ideally, the grout is mixed in a concrete-mobile truck, by hand in the bucket of a bucket loader, using conventional civilian grout equipment, or by other means that will accomplish the mission.

Add the calcium chloride accelerator to the grout mix once the grout has reached the 8-inch level in the crater.

Place 3-inch (56 to 75 millimeters) uniformly-graded stone into the grout until the stone level is even with the existing pavement.

TABLE B-1. STONE AND GROUT MIX PROPORTIONS

GROUT MIXTURE*	PERCENTAGE BY WEIGHT	WEIGHT OF ADDITIVE PER CUBIC YARD
Portland Cement	67.8	2203.2 lb (999.4 kg)
Calcium Chloride (Accelerator)	1	32.67 lb (14.8 kg)
Friction Retarder	0.2	6.68 lb (2.9 kg)
Water	31	1004.4 lb (455.6 kg)

*This mixture will develop at least 1,500 psi compressive strength in 24 hours.

The stone should be worked down through the grout until all stone has been covered with grout and a uniform cross section exists. This is best accomplished by initially walking a bulldozer back and forth across the crater. A vibratory steel wheel roller is then used to compact the grout cap, causing a thin layer of grout to percolate through the stone to top. It is critical to keep the uniformly-graded material free of contamination from fines to ensure good percolation.

The final level of stone and grout should be within 1 inch of the surrounding pavement. Add grout and stone until the surface of the cap matches the level of the existing pavement. No aggregate should extend above the crater surface. The final surface should be finished until smooth and level with existing pavement.

Placement at or Below Freezing Temperatures

Special considerations must be made when placing the stone and grout mixture in freezing temperatures. There are several methods which can be employed to help ensure successful mission accomplishments:

- Add additional calcium chloride accelerator (up to as much as 3 percent by weight from the normal amount of 1 percent) to the solution of stone and grout to decrease the set time.
- Heat the aggregate. This can be done in a tent surrounding aggregate stockpiles.
- Heat the water. One possible method is to use immersion heaters. It is best to heat both the water and the aggregate, rather than just one. This helps ensure that the extremely cold condition of either component will not offset the heated condition of the other. Do not mix the water and aggregate until the last possible moment.
- Do not uncover the subgrade until immediately before placement to allow heat to be retained. This necessitates a change in repair priorities since several craters cannot be worked on concurrently (as their subgrades would be left exposed while awaiting grout). Rather, one crater is completely repaired before moving on to repair the next.
- Place an insulated blanket over the finished concrete surface. One possible composition of this blanket is a layer of impervious membrane, approximately 10 inches of straw or hay, followed by an additional layer of impervious membrane.

SUMMARY

While the concrete or the stone and grout cap repair methods may be employed to conduct beyond emergency repair, one may be more feasible than the other due, to availability of materials. For example, the concrete cap method greatly depends upon the availability of host nation support. The stone and grout repair method is less dependent upon host nation support, since it requires materials often available to engineer units in times of conflict. The advantages and disadvantages of emergency repair and beyond emergency repair methods are shown in Table B-2 on page B-8.

TABLE B-2. ADVANTAGES AND DISADVANTAGES

		ADVANTAGES	DISADVANTAGES
EMERGENCY REPAIR	SAND GRID	Simple Low cost Lightweight Little storage space required Air transportable	Frequent maintenance Needs suitable filler material Requires FOD cover
	STONE AND GROUT CAP	Material availability Applicable for troop on-site mixing	Requires the largest number of troop man-hours and equipment hours
BEYOND EMERGENCY REPAIR	HIGH/EARLY CONCRETE CAP (TYPE III)	Smooth finish Easy placement Maintenance free	Poor results in freezing weather Needs pedestal Host nation support needed
	TYPE I/NORMAL CONCRETE CAP	Readily available and familiar Not as expensive as High/Early concrete Smooth finish Maintenance free	Poor results in freezing weather Needs pedestal Host nation support needed

While several other concrete types (such as Reg-Set concrete) have been tested for crater repair, the methods listed in this appendix are the only acceptable beyond emergency repair solutions.